ON THE MICROSCOPIC AND GENERAL CHARACTERS OF THE PEACH TREE AFFECTED WITH THE "YELLOWS."

BY W. K. HIGLEY.

[*Continued.*]

METHODS OF DISSEMINATION.

I DESIRE under this head to simply discuss the views of others, and in doing this to present my own views upon the subject. First, then, I will consider the belief of some that the yellows may be transmitted from one tree to another by the agency of insects, especially the honey bee, by carrying the pollen from one flower to others. Believing, as I do, that this disease is due to a fungoid growth in the *aërial portions of the tree*, this theory appears to me very absurd, more so, perhaps, because there are no facts or experiments to support it. Consider for a moment. If this disease is due to a fungus, then it must be disseminated by the passage of the spores or living mycelia from the diseased tree to other trees, either in the immediate neighborhood, or perhaps to some distant tree if the conditions are favorable for their transportation. If this is the case, and all, I think, that have carefully considered the facts, must know that it is, why should the fruit of the fungus be concentrated in the pollen? Why is it that young orchards that have never borne become contaminated with this disease? Why is it that orchards in close relation with other orchards that are affected with the yellows do not become diseased? We cannot assume that the bees will not visit both orchards! And finally, why is it that in the same orchard with healthy trees only one or two trees catch the yellows, showing all the symptoms, and the second year only one or two, or at the greatest only a few in the immediate neighborhood become diseased? Are we to assume that the bees in their search after their food are limited and not allowed to approach only certain trees?

Perhaps this is strong language to use in the face of all that has been claimed, but until the above questions are satisfactorily answered, I shall refuse to believe that insects have anything to do with the dissemination of this disease.

In concluding the discussion upon this point I will quote from the Michigan Pomological Report for 1878. On page 255, *it*

says: "Those who believe in the propagation of the disease by the agency of insects, maintain that the disease is never manifested upon healthy stock until after the young tree casts its first blossoms, and experiments for the purpose of testing their theory will be made by enveloping the young tree with netting, in such a manner as to exclude all insects during the period of bloom." However, the disease does appear very often on trees that have not blossomed!

On page 250 of the same volume, referring to the abnormal branching, it says:

"*This growth is the only means of detecting the disease in young trees or those not bearing.*" (The italics are mine.)

In the Pomological Report for 1873, under this head, the first and second methods of dissemination given, are as follows:

1. "By the intermingling of healthy roots with those of diseased trees.
2. "By planting a healthy tree in a hole whence a diseased tree has been removed."

As I have stated before, all the roots that were examined by me, presented no abnormal appearance except the looseness of the cells; in no case were any filaments of a fungus found in the tissues, nor any spores, nor any indications that a fungus had ever been present. Those that claim that the disease is caused by a root fungus, have never, to my knowledge, found any species of fungi that is peculiar to the peach root, which is not found in many other roots as well. In my examinations I have found fungi growing upon the outside of the larger roots, but in every case I have turned immediately to the oak root and found the same condition of things there, and the oak did not have the yellows, and as far as could be seen, no disease of any sort. Not having found any signs of a fungoid growth in or on the root that is not found on the roots of most any tree, I do not believe that this disease can be transmitted from one tree to another by the first means given above.

As to the second, if the fungus that causes the disease has had time to mature and give off its spores, it is probable that many of them would fall upon the ground round about the base of the tree, and thus, if the tree is removed and another put in its place, the spores may, by some means, get upon the bark of the new tree and there, germinating, push their filaments into the tissues.

But this can not often be the case, as cases are on record where orchards have been planted on the same ground from whence diseased trees have been removed, and remained healthy.

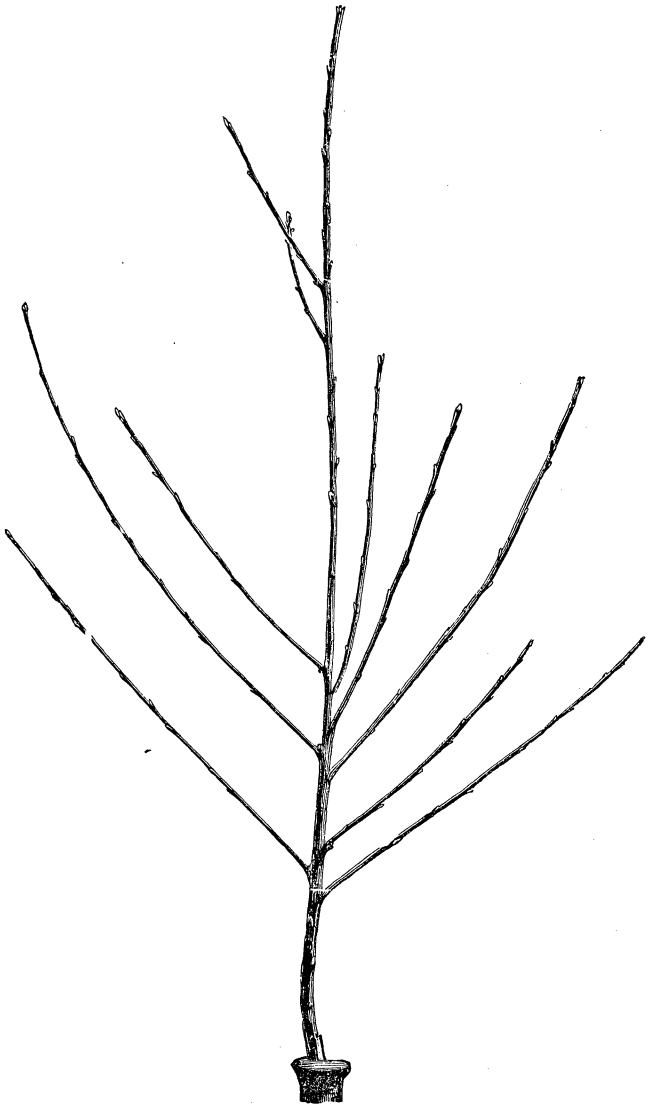

FIG. 1.—Healthy limb of peach tree.

I have no doubt that by using the buds of diseased trees in budding, the yellows may be carried from tree to tree; for living mycelia or some of the fruit-bearing filaments may be present in

the bud and thus when placed in the new tree the fungus continues to grow and the spores to germinate, and soon the tree succumbs to the disease.

The transmitting of the spores or mycelia by the pruning knife, is still an obscure method of dissemination. There is no doubt, however, that the disease is carried in this way very often.

Another and very important method of dissemination, is the transplanting of trees from diseased districts. Perhaps and probably, the yellows is introduced into new localities as often in this way as in any other. We can not accuse any one of dishonesty in selling plants which are diseased, for many do not know what the symptoms are, and still others honestly believe that it is nothing of importance.

I have left what I consider the most important method until the last. It is the spreading of the disease by the germs or spores being carried by the wind. It seems to me that the appearance of the yellows in isolated places and localities is strong evidence of this. Some may ask, why is not the disease more general if this is the case? I think that it can be affirmed that the disease is already general. It has been reported from all the leading peach districts and new localities are found every season. Especially is its sudden appearance in orchards at a short distance from infected districts to be taken into account. It is well known that no matter what the conditions of the atmosphere may be, the spores of fungi are always floating about, wafted hither and thither, lighting upon various organic individuals, until the true host is found, and then remaining only to send into the tissues its filaments, forming its mycelia, and finally throwing off other spores to be transported in a like manner as were those of their parent. If this trouble has its origin in a fungoid growth, the spores are just as certain to be carried from place to place by the wind as are those of any other species that grow upon other plants.

It will be seen from the above discussion upon this division of the subject, that I have included what is generally placed under the head, "Is this disease contagious?" Believing that it is not a constitutional disease, but one due to a parasitical vegetable growth, I think that it is more proper to say that the disease is disseminated in this way or that, rather than to say that it is contagious and may be caught by the healthy tree.

CAUSE.

The most important part of the discussion we now have to consider; for, knowing the cause, we can then suggest a remedy much more easily.

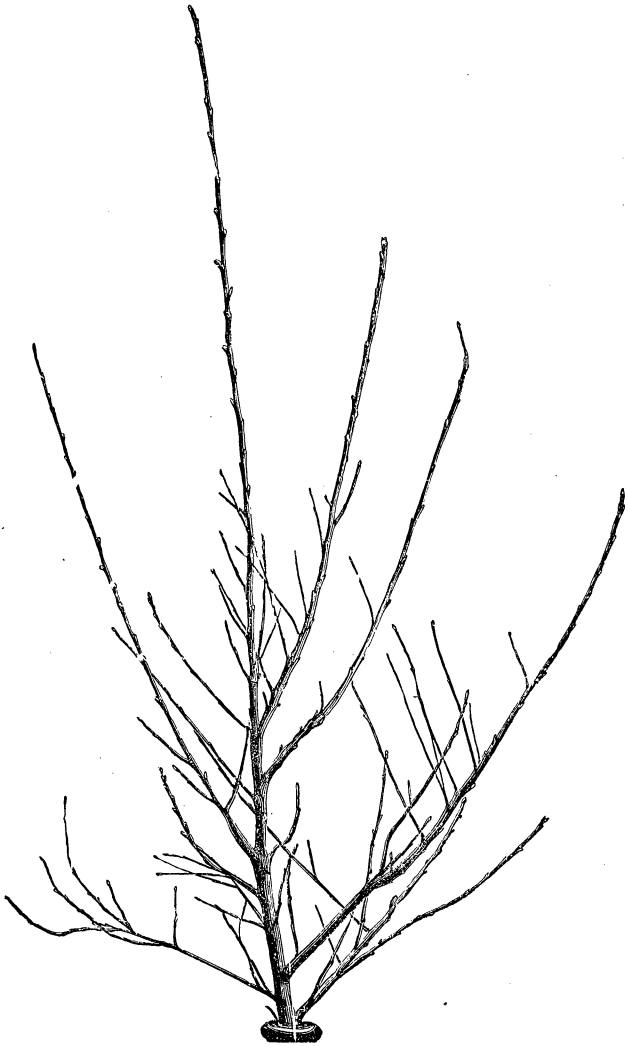

FIG. 2.—Unhealthy limb, showing the abnormal branchlets.

The yellows have been attributed to both animal and vegetable origin as well as to exhaustion of the system of the tree. The former has had many advocates, but these are becoming fewer

every season. As no facts in support of this theory have ever been published to my knowledge, I shall consider it no further.

The weight of the evidence is in favor of the vegetable origin, and, from my observations, I firmly believe that it is due to a fungoid growth. Thos. Taylor, of the Department of Agriculture at Washington, claims that he may have discovered the cause of the disease in a species of Nœmaspora. But the same form is reported as occurring on other trees that received no harm from its presence. Spores of this genus are known to be in the air, and may as often light on other trees as on the peach; and it has been demonstrated that they will develop upon the oak bark as well as on that of the peach, when the conditions are favorable. Some may wish to ask: "Is not that upon the oak a different species?" This is a just and scientific question that immediately arises when such a fact is reported in an investigation like this; my answer will be apparent soon. First, however, let us see how Mr. Taylor proceeds to experiment: [1] "On the 1st of July last I commenced a series of experiments, by the moist process, with the bark of a peach tree affected with the yellows. Into five glass receivers I placed, respectively, a few drops of water, just sufficient to form a moist atmosphere in each. Into No. 1 I put a piece of bark affected with the yellows; into No. 2 a piece of bark from a healthy peach tree; into No. 3 a handful of peach leaves from the unhealthy tree; into No. 4 a similar quantity from the healthy tree; and into No. 5 portions of bark from the healthy and unhealthy trees mentioned. All the specimens were secured from the outward atmosphere. The temperature of the room in which the specimens were kept was frequently at 90° F. *These conditions were highly favorable to the development of such fungous germs as mature under excess of heat and moisture.*" (The italics are mine.)

After due time has elapsed, he finds mycelia and spores of Nœmaspora on specimens in receivers Nos. 1 and 5, and says that seemingly the healthy bark in No. 5 was not affected by the contact with the unhealthy bark. We are left entirely in doubt as to what occurred in receiver No. 2. I have carefully followed his experiments in my own work, and am able to report that the same forms of Nœmaspora may be found on the healthy bark as well as on the unhealthy, and further, that the same forms are

[1] Mich. Pomological Report, 1872, p. 593.

also found upon and may be developed on the oak bark. I tried the experiment with two specimens each of the healthy and unhealthy peach bark, and also two specimens of the oak bark. The directions given above, from Mr. Taylor, were closely and carefully followed. The healthy bark used was from vigorous

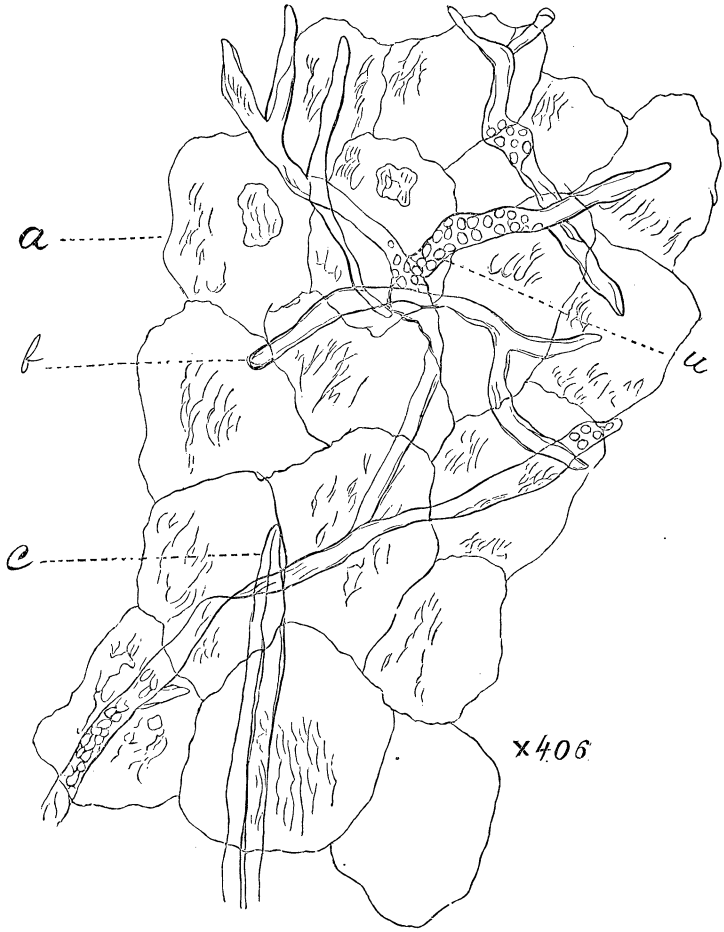

FIG. 3.—Filaments of a fungus found in the tissues of the fruit, and drawn with camera lucida (× 406). *a*, cells of the fleshy portion of the peach; *b*, filaments of the fungus, showing the globular bodies, and at *u* perhaps the fruit just forming; *c*, portion of the hair of the peach skin.

trees growing at my home in Ann Arbor, while the unhealthy specimens were from South Haven, Mich.

Some, and perhaps I might say many, think that the disease is caused by a fungus in the tissues of the root, but none, to my

knowledge, has ever been recorded as occurring there. I have already sufficiently discussed this theory under the head *Dissemination of the Yellows*, and think that nothing further can be said about it unless more facts are brought to light. Nevertheless, I wish to quote a passage—a statement concerning this matter which my observations strongly confirm: [1]"The fungus found upon the roots of decayed peach trees is indigenous to all dead and decaying woods, and is the effect, and not the cause of such decay. Many thousands of trees which have been stricken by the disease, have been removed by 'drawing out;' the crowns, and roots of such trees invariably show a sound and healthy appearance."

Some have suggested that the disease might be zymotic in its nature. Mr. C. H. Peck, State Botanist of N. Y., has examined diseased specimens with this idea before him, and his results I give in full:[2] "The juice of an affected peach was carefully examined, but a power of four hundred diameters failed to reveal any spores or ferment cells. Thin sections of the leaves were made, and the leaf cells examined. A marked difference was observed between the cells of leaves from healthy trees and those of leaves from diseased trees. In the former the cells were well filled with a uniform mass of green chlorophyl, in the latter the chlorophyl was badly disorganized, very much broken up, shrunken and discolored. Many of the cells appeared to be nearly empty, and one or more minute, globose, shining bodies were seen among the fragments of the chlorophyl. An important step seemed now to have been taken in the investigation, but farther examination convinced me that these shining bodies were only the altered nuclei of the chlorophyl. It is scarcely possible that they could be foreign organic bodies, for how could they enter the walls of the unruptured cells? It was found that leaves discolored by the attacks of insects had the chlorophyl of the faded cells in a similar shriveled and abnormal condition. Various autumnal leaves, colored by nature's process, show similar shining nuclei in their cells, which also sometimes have their endochrome in a collapsed condition. Nothing like a ferment cell was disclosed in the leaves; but whatever may be the cause of this peculiar condition of the chlorophyl in leaves from affected

[1] Michigan Pomological Report, 1878, p. 254.

[2] *Cultivator and Country Gentleman*, Oct. 30, 1879.

trees, it is easy to see that it must be a serious matter to the tree. The leaves are its lungs and its stomach. Respiration and digestion are carried on through them. If, then, the active vivifying power of the chlorophyl is impaired, as it must be in such a disorganized condition, the sap must cease to be properly elabo-

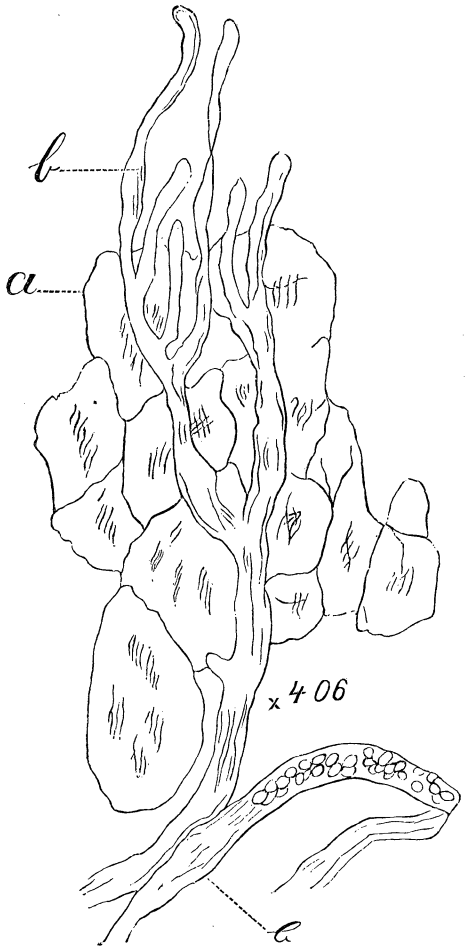

FIG. 4.—Same as Fig. 3.

rated, and the tree must suffer. It is very much as if a man were afflicted at one time with both consumption and dyspesia. No wonder that the tree at length dies."

To observe the action, method of growth, position and the character of this intruder, has been the object of my work since

the 1st of August, 1878. I have endeavored to do my work carefully, microscope in hand as a constant companion, and will now give the results of my labors, and present what I verily believe to be the cause of the disease.

From the start I have worked with this idea before me; that if the disease was caused by a fungus, this particular fungus must be present in the tissues of the tree as it stands in nature, or, in other words, *the conditions natural to the growth of the tree must also be natural to the development of the fungus.* Making this the basis of my observations and experiments, I did not produce the conditions favorable for the growth of most fungi, viz., a moist atmosphere or a high degree of warmth, but simply examined the specimens as they were gathered from the diseased trees and sent to me. The specimens, when I examined them, were all in good condition; the fruit was not in the least decayed, but in all particulars perfectly natural. Some of the peaches were immediately sliced and placed in alcohol on their arrival, and others were examined while fresh. The results were the same in both cases.

For the sake of convenience I will give the results of the examination of each part of the tree in the order of succession of those parts.

1. *Roots.*—First, a specimen four inches long and about one-eighth of an inch thick was examined; sections being made one-fourth inch distant from each other. Second, a root four inches long and one-half inch in diameter, sections being made as before. Third, a root of the same length and one inch thick was examined as in the first specimen. Fourth, sections cut in no regular order from roots of various sizes and trees. All of the above sections were examined with objectives varying in their magnifying power between 75 and 625 diameters, and in no case was any fungoid growth seen in the tissues nor anything in the least abnormal except the loose structure which has been mentioned before.

2. *Trunk.*—Many sections were made from various sized specimens, the largest two inches in diameter, and the smallest, one inch. Sections of the bark showed rather too much coloring matter, and in the inner bark of the larger specimens I noticed an abundance of mycelia, the characters and appearance of which will be given under the head *Fruit.* The smaller specimens did

not show near as much of the fungoid growth as did the larger, and, indeed, I examined several sections before I found any mycelia at all. In both cases it was situated on the under side of the inner bark, next to the cambium layer, and many of the filaments penetrated and ramified through this layer. I also noticed, in the larger specimens, mycelia between the layers of wood. An examination of the abnormal pigment spots, scattered through the pith and woody portions, revealed nothing but cells filled with the coloring matter. The outer bark in no case showed signs of any fungoid forms.

3. Branches.—An examination of the larger branches revealed nothing at all different from that given above for the trunk of the tree; but some of the smaller branches and the growing ends of the larger or main branches, showed marked peculiarities indeed. In these the tissues seemed to be completely filled with mycelia, and in one case the bark was apparently split.[1] The branches from which these specimens were taken had many abnormal branchlets, and hence the theory advanced in the first part of this paper that these abnormal shoots were caused by the filling up of the tissues of the growing ends, thus turning the flow of sap to the lateral buds.

The filament found in the branches was in all respects identical with that found in the trunk of the trees, and will be described further on.

4. Leaves.—Those examined were mostly from the abnormal branchlets. The chlorophyl in all was completely disorganized, and in general the appearance was the same referred to by Mr. Peck. It seemed at first that this must be caused by dry weather or lack of cultivation, but on further examination filaments of a fungus were found to be present, to a greater or less extent, in nearly all the leaves examined. I noticed but two spores of any sort in the tissues, these were teleuto-spores and without doubt belonged to some leaf fungus other than the one the filaments of which were found in the tissues. On a few of the leaves sent me I found the fungus *Ascomyces deformans*, which causes the "curl leaf" disease so common at the present time in many localities.

The filaments of the fungus alluded to first, were of the same character as those that will be described under the next head.

[1] A friend to whom I showed this, suggested that this splitting might have been caused by the pressure of the growing mycelia within the tissues.

Mr. Thos. Taylor says, that [1] "it is evident that the healthy leaves possess an antiseptic substance which prevents the growth of the common moulds on them." The results of my experiments have led me to the same conclusion. An analysis of the

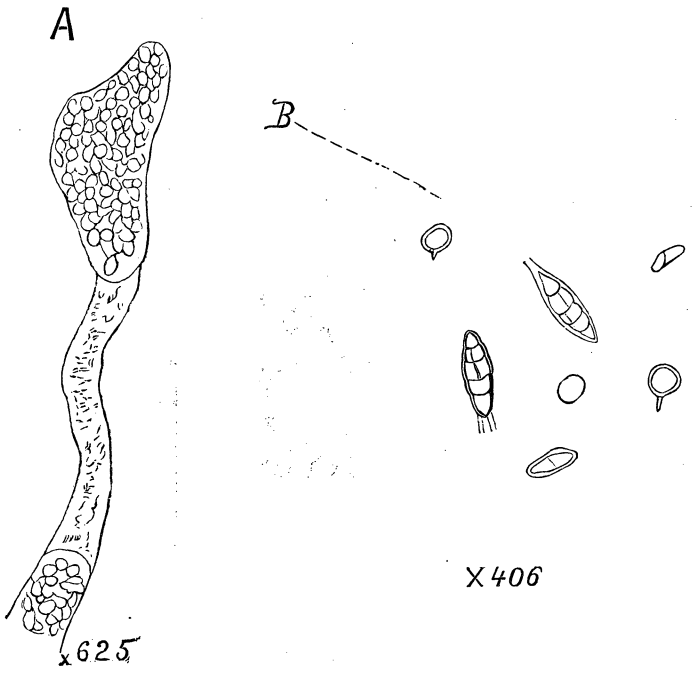

FIG. 5—A, fruit of a fungus found just beneath the skin of the peach. This resembles a portion of the fruit of the Saprolegnieæ (× 406); B, spores formed in the peach. Drawn with the camera lucida (× 406).

leaves show that there is a much larger proportion of moisture in the diseased leaves than in the healthy. I analyzed several specimens of each and found a greater difference between them than Mr. Taylor reports.[1] However, this is not important, as the per cent. may and does vary much. The average of my analyses was as follows:

HEALTHY LEAVES.

Moisture	25.62
Organic matter	69.24
Ash	5.14
	100.00

[1] Mich. Pomological Report, 1872, p. 597.

UNHEALTHY LEAVES.

Moisture	39.16
Organic matter	57.08
Ash	3.76
	100.00

There is a small per cent. of volatile matter in the leaves that in the estimation would raise the per cent. of moisture slightly.

It will be seen from the above results that the unhealthy leaves are much better fitted to become the host of a parasitic fungus than are the healthy ones.

As to what causes this abnormal amount of moisture, I have already formed an opinion, but desire to confirm it by further experiment, the results of which I hope to include in a future paper devoted entirely to this subject.

5. Fruit.—I found that the most satisfactory results were to be obtained from an examination of the fruit, and therefore spent the greater part of my time upon that portion of the tree. Mycelia in abundance were found just beneath the skin, extending into the fleshy parenchyma a short distance. This fungus—identical with that found in the other parts of the tree—was unicellular, branching, and much enlarged in places. In some places the filaments were apparently filled with small oil globules and bodies closely resembling spores. In only a single instance did I find a distinct fruiting filament. That I did not find more of the fruit I regret very much, for in order to know fully the characters of a fungus, its fruiting system must be carefully studied.

The single specimen of the fruit I examined is shown on Fig. 5. It was found beneath the skin of a prematurely ripened peach, detached from the remaining filaments present with it, and yet evidently it belonged to the same growth.

Several peaches were examined, and in no case did I fail to find the same branching form.

The method of branching and the form of the filament (shown on Figs. 3 and 4), as well as the oil globules which they contained, and the fruiting system of this fungoid growth, immediately reminds one of Saprolegnieæ, to which division of fungi this form seems to belong. And as the final result of my investigation up to the present time, I believe this parasitical vegetable form to be at least a part of, and probably the whole cause of this disease.

Many modes of procedure have been suggested to effect a cure

and thus save the trees. Those persons advancing some of them claim that their *modus operandi* is a sure and active agent in bringing about the desired end. But most of the modes are simply theoretical and always fail. In most cases when a cure has been reported, it has afterwards been proven that the tree did not have the yellows at all. For example, one who attributed the yellows to an animal origin, used Paris green, throwing it over the tree with a pump, and the next year the trees that he supposed to be diseased were in a healthy bearing condition. It was afterwards shown that the symptoms of the yellows were

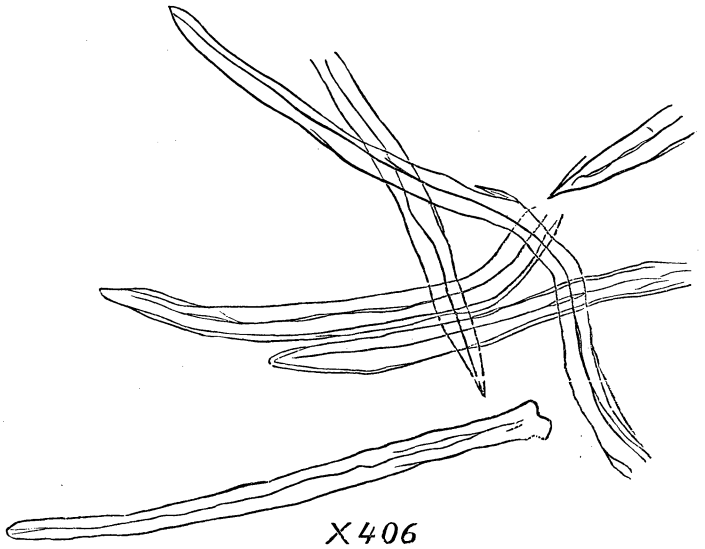

FIG. 6.—Hairs on the skin of the peach (× 406). Drawn with camera lucida.

produced indeed by an animal, but that animal was simply a plant louse! The tree being covered with them, the Paris green was an effective agent in ridding the orchard of its pest.

Some have used hot or boiling water, pouring it about the roots of the trees, and in many cases they have reported the disease reduced; but in every case that has come under my observation it has failed.

It is not at all surprising that the means used—including the whole category of remedies—have often been reported as producing a satisfactory cure, for *many of the temporary injuries liable to come upon a tree, will, in most instances, produce many of the symptoms of the yellows;* these are the cases that have been

cured. If they had been left alone nature's physician would have cured them also. *Nature does not cure the yellows.* A severe frost will kill the heart wood of a tree, producing some of the characters of this disease, but the exterior—the vital part—remaining unharmed, it will soon return to its healthy condition.

Disinfectants have been recommended. Mr. A. G. Gulley says upon this subject:[1] "But I look with hope in another direction, that of preventives by which we can disinfect the trees or enable them to resist or throw off the disease. This idea is strengthened by the evidence that a fungus may be the cause. We know that the low forms of vegetable life are destroyed by various substances and cannot exist in their presence. If the disease is of that nature, by the introduction of some of those materials we shall disinfect the trees, destroy the germs or prevent its growth."

We agree with Mr. Gulley in this, but as far as experiments have been tried, the right substance has, as yet, not been found, and it is a query whether or not the very agent that may be destructive to the fungus may not also, being unnatural in the circulation of the tree, destroy it also.

Mr. Taylor[2] recommends the use of sulphates and alkalies as a wash to be used on the bark and roots of the trees. It must be borne in mind, however, that he is inclined to attribute the disease to the agency of a species of Nœmaspora, which I think has been clearly shown is not the cause, but that the fungus that produces the yellows, both fruit and mycelia, is more internal than he claims, and would thus necessitate the introduction of the acid, alkali or any disinfectant into the circulation, which would produce an abnormal condition of things physiologically, and injure the tree itself. I have no doubt, however, that if enough of these reagents were used the fungus would be destroyed.

Dr. Kedzie's recommendation[1] of the use of potash and phosphoric acid or superphosphate of lime as an experiment, we consider as simply a good preventive, and have discussed it under that head.

From my work and observations, and from, I think, a scientific standpoint, letting theories alone, the only cure that I can recommend, is, that the fruit grower, when he notices that any tree in his orchard has become diseased, root it out carefully and burn

[1] Mich. Pomological Report, 1878, p. 252.

[2] Mich. Pomological Report, 1872, p. 596.

every part. If each one takes this care and is also careful to keep the orchard up to the standard cultivation, this malady, which is troubling our orchardists to such an extent at present, will surely fall and soon become a thing of the past.[1]

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INTELLIGENCE IN A SNAIL.

BY W. H. DALL.

SOME time since a relative told me a remarkable story about a child who had pet snails which recognized her voice and distinguished it from that of others. As such a development of intelligence has not hitherto been reported among mollusks, I was much interested. By the kindness of the lady from whom the story was first heard, and the intervention of Mrs. Lay, wife of Bishop Lay, formerly of Arkansas and now of Maryland, one of the family, who was cognizant of the facts, was reached, and an extract from her letter is appended. I may add that Mrs. Lay speaks in the highest terms of the accuracy and clearheadedness of her correspondent (then and now a resident of Arkansas), and remarks that both she and her sister were remarkable for the ease with which they established friendly and confidential relations with the birds and animals about them. The father of these ladies, whose name I suppress merely because I have not their authority to print it, was chief clerk in the State Department under the secretaryship of Daniel Webster.

The malacologist, familiar with pulmonates, will recognize in the following quotation many facts which indicate the accuracy and unusual powers of observation of the writer. It is probable that the snail was one of the group to which *H. albolabris* belongs, at all events it was a native of Arkansas and one of the larger species. It would be highly interesting if some of our lady friends would repeat the experiment with different kinds of snails, and determine by additional evidence whether they are capable— 1st. Of recognizing a call or sound; and 2d. Of distinguishing it from other similar calls or sounds; which the snail in question appears to have done.

[1] Mr. David De Tarr, of the Zoological Department of the State of New York at Albany, and Mr. A. B. Covert, of Ann Arbor, Mich., were, during a part of the time of the above investigation, associated with me. To Mr. De Tarr may be credited the finding and drawing of the fungoid form figured on Fig. 4.